Abstract

Recent advances in computer technology have resulted in the emergence of a new area of computational mechanics which can be broadly classified as Biologically Inspired Computational Methods (BICMs). In particular, Knowledge Based Expert Systems, Artificial Neural Networks and Genetic Algorithms are increasingly being assigned tasks of ever increasing complexity and are expected to perform tasks which till recently belonged to the exclusive domain of human beings. It is well recognized that in most of the engineering activities, the knowledge or information that is made available to produce the decisions is of varying quality - infact, the quality of the different segments of knowledge varies between the extremes of absolute precision and total ambiguity. In the light of these observations, the principal research effort in this thesis is directed towards devising efficient BICMs, which are equipped to handle uncertain information and towards evolving efficient strategies to employ these BICMs to solve a special class of problems in continuum structures - design and damage assessment - which are characterized by the complexities arising from the inverse nature of the problem and the ambiguity that shrouds the description of various system parameters. The paradigms involved in both the tasks, namely, design and damage assessment, are different. While the former is dependent on computational skills, rules and procedures involving logical reasoning, the latter relies heavily on cognitive skills to recognize patterns, images, etc.

In particular, this investigation addresses three BICMs, viz., Fuzzy logic Integrated Knowledge based Systems (FIKS), Fuzzy logic Integrated Neural Networks (FINN) and Genetic Algorithm based Method (GAM). As a typical example of a complex engineering decision making environment in which uncertainties also play a major role, fibre reinforced composite structural elements employed primarily in aerospace applications is selected. The research effort is conducted in three parts. In the first part, a knowledge based expert system is developed for the design of a laminated composite structural element to be employed for aerospace applications using the FIKS paradigm. The uncertainties encountered at the various stages of the design are mathematically represented as Fuzzy sets and relevant design decisions are arrived at through the expert system by following

the rules of Fuzzy Logic In the second part, the damage suffered by a composite structural element during its service is diagnosed and its magnitude is estimated This exercise is done through the use of Artificial Neural Networks appropriately configured both to diagnose and to assess the extent of damage Even here, the ANN is integrated with Fuzzy Logic to form the generalized architecture FINN so that uncertain input information can lead to approximate reasoning of the output In the third part, designing the GA to perform the unconventional task of damage assessment in contrast with the readily obvious applications of GA for a design optimization task, is carried out

The thesis is laid out in six chapters with the last chapter dealing with the discussion of results, conclusions and suggestions for further work Following contributions are made through the investigations carried out in the thesis

The investigations carried out clearly bring out the power of BICMs to assist in the human decision making effort, in the class of problems considered in the thesis Modelling the uncertainties, specific to the class of problems considered, using fuzzy sets is demonstrated By impregnating Expert Systems and Artificial Neural Networks with approximate reasoning strategies using Fuzzy Logic, the BICMs, FIKS and FINN are able to emulate human behaviour more closely The Expert System developed (DELCOM EXPERT) using the FIKS paradigm also incorporates an intelligent way of decision making through the decision support system developed based on the analytic hierarchy approach and is expected to be a significant tool for the designer Efficacy of ANN in the damage assessment problem is demonstrated using a modular network approach With the proposed FINN architecture, the conventional Back propagation Neural Networks can be trained with deterministic data and yet it can be used against fuzzy input at the end-user level The Haar transform based impulse indices employed to preprocess the vibrational response give simple, easily distinguishable, representative patterns compared to the time domain or frequency domain data and are computationally more efficient GAM is shown to be a very promising tool for the damage assessment problem. The novel formulation of the damage assessment problem identifies the location and magnitude of the damage simultaneously with the power of GAM thereby underlining the scope of BICMs in solving complex structural engineering problems